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INTERMOUNTAIN REGION AND METHODS APPLICATION GROUP FOREST INSECT AND DISEASE MANAGEMENT FOREST SERVICE, USDA

A PILOT SURVEY TO MEASURE ANNUAL MORTALITY OF LODGEPOLE PINE CAUSED BY THE MOUNTAIN PINE BEETLE

William B. Klein,
Dayle B. Bennett &
Robert W. Young

ABSTRACT

A pilot survey utilizing multistage sampling techniques was undertaken on the Targhee National Forest during 1977 to measure annual mortality of lodgepole pine by the mountain pine beetle. The survey area, 397,000 acres, was stratified by aerial sketchmapping into three intensity classes; each stratum was independently sampled by large scale (1:6000) color aerial photography and ground truth. Additional stand data was taken on randomly selected ground plots.

The correlations between photo and ground counts for each stratum were generally good. Stratification by aerial sketchmapping reduced the population variance and improved the sampling errors. Mortality estimates of mountain pine beetle-killed lodgepole pine for 1976 were 3,609,627 trees and 64,761,000 cubic feet. Prior to 1976, the standing dead lodgepole pine was estimated at 17,751,000 trees and 249,515,000 cubic feet. The basal area ratio of the residual green stand to total dead was 63%.

Mountain pine beetle damage surveys will be conducted in portions of Montana, South Dakota, and Wyoming in 1978. Methods will be essentially similar to this survey with some modifications.

A PILOT SURVEY TO MEASURE ANNUAL MORTALITY OF LODGEPOLE PINE CAUSED BY THE MOUNTAIN PINE BEETLE[1]

William H. Klein, Dayle D. Bennett, and Robert W. Young[2]

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EXPERIMENT STATION

1 A synopsis of this report was presented at the Workshop for Vegetation Damage Assessment, Seattle, Washington, February 15, 1978. Proceedings to be published.

2 Respectively, Survey System Specialist, USDA Forest Service, FI&DM Methods Application Group, Davis, CA; Biological Technician, USDA Forest Service, State and Private Forestry, Missoula, MT; and Biometrician, USDA Forest Service, FI&DM Methods Application Group, Davis, CA.

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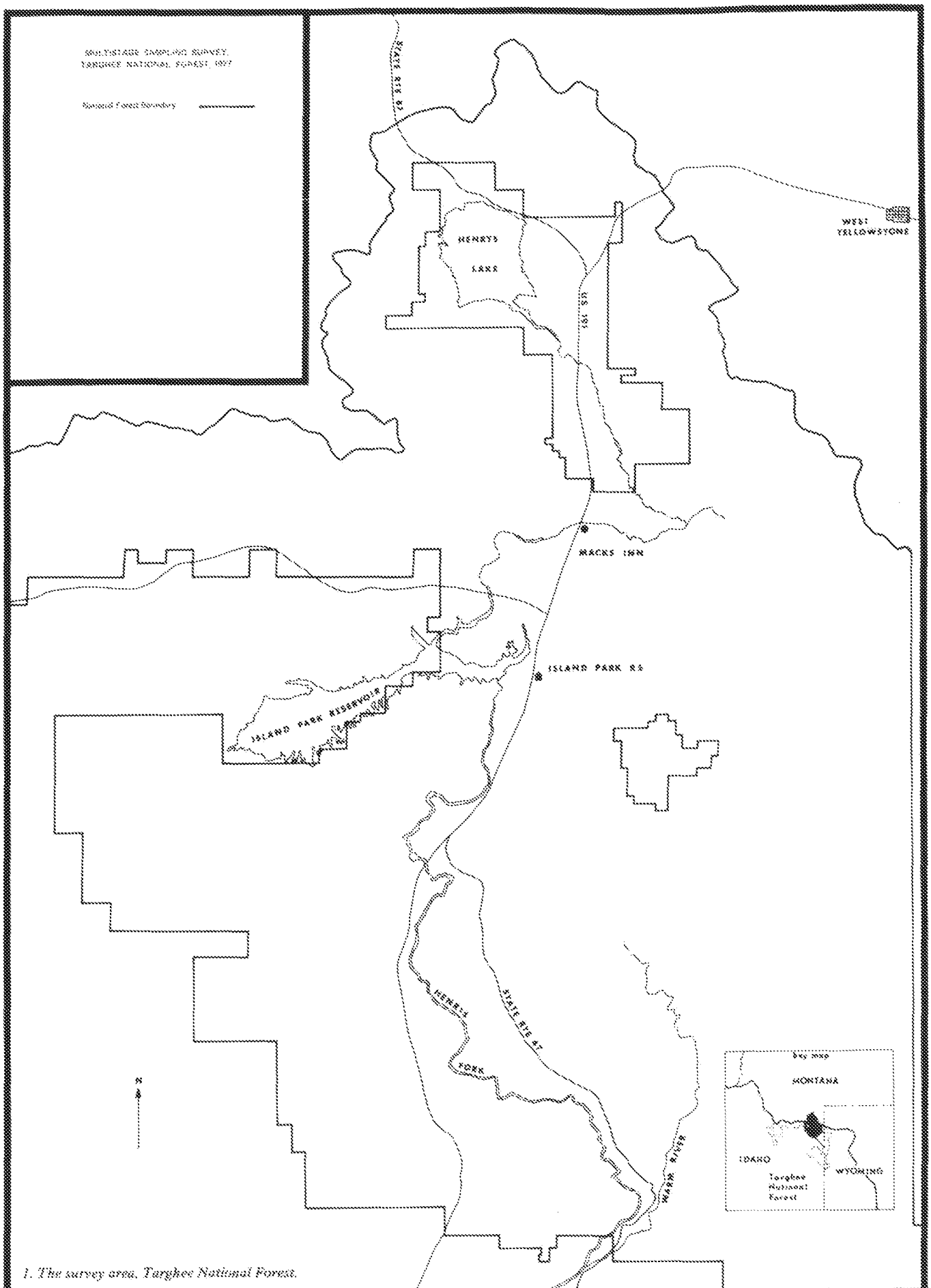


1. The survey area, Targhee National Forest.

INTRODUCTION

Forest insects and diseases kill more timber than all other causes combined, including fire. The most damaging group of these tree-killing agents in the western United States is the coniferous bark beetles. Annual losses may vary from only one or two trees per 1000 acres during endemic periods to over 30 trees per acre during full scale outbreaks[3]. Forest managers and program administrators are generally aware of these losses and to some extent their location, but due to both the periodic and extensive nature of most bark bettle outbreaks, they lack accurate and timely data on the extent of this damage. These losses and their resulting impact, whether only partially or fully known, affect both short- and long-term management goals, making it imperative that they be accurately monitored and quantified.

During 1977, two pilot surveys were conducted to measure annual mortality caused by the mountain pine beetle, *Dendroctonus ponderosae* Hopkins. One survey was conducted in ponderosa pine, *Pinus ponderosa* Laws. on the Black Hills National Forest in Wyoming and South Dakota, and the other was conducted in lodgepole pine, *Pinus contorta* var. *latifolia* Engelm. on the Targhee National Forest in Idaho. Design and procedures used for the surveys were agreed to by a specially formed Working Group comprised of individuals from most of the western Regions and from Research (see Appendix). This report describes only the survey conducted on the Targhee National Forest.

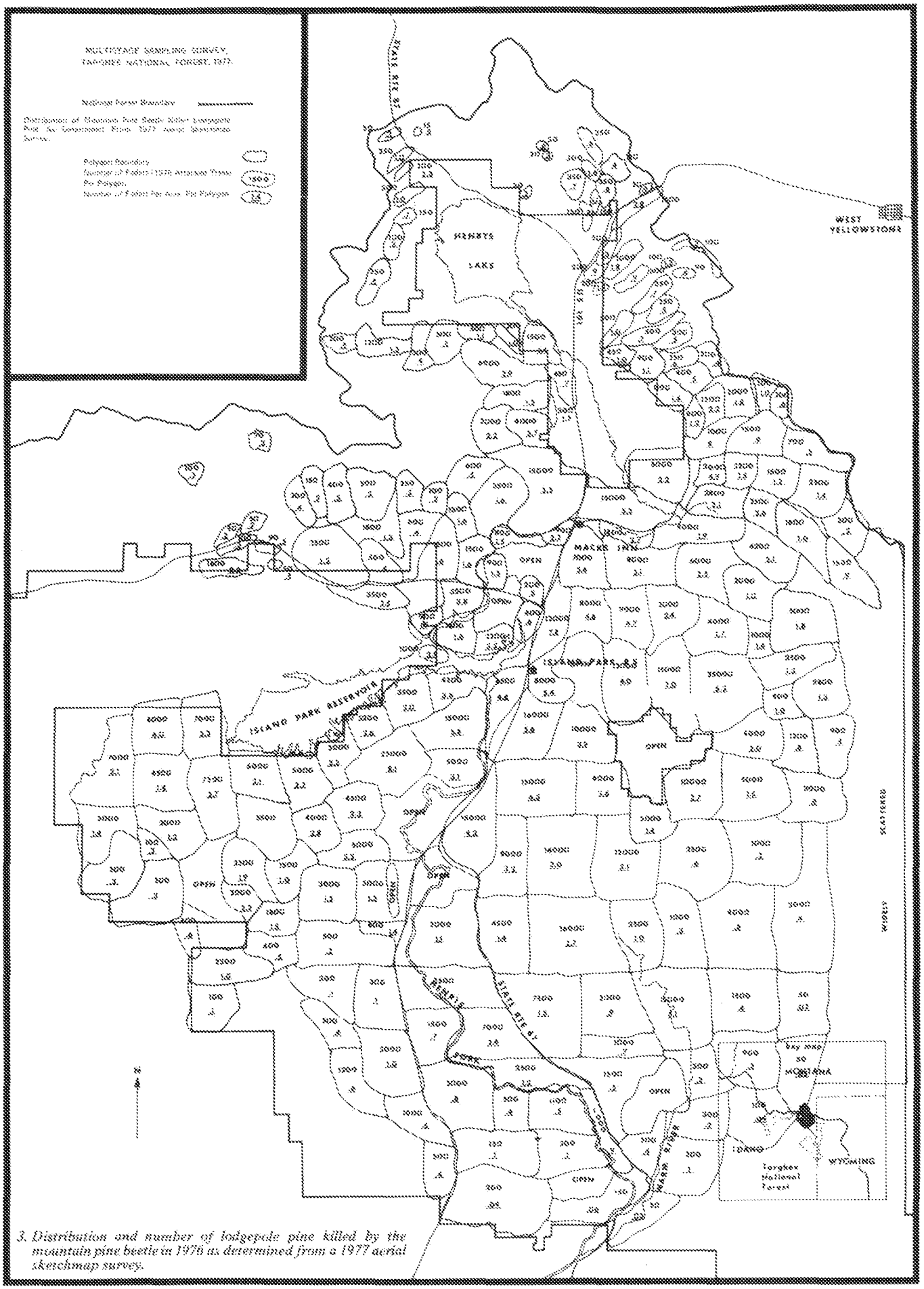
3 Gibson, Kenneth E. and Dayle D. Bennett. 1978. Damage assessment of a mountain pine beetle infestation on the Targhee National Forest. USDA Forest Service, Intermountain Region, Ogden, Utah.

OBJECTIVE

The objective of this survey was to design and implement a multistage sampling system utilizing existing technology for measuring annual mortality of lodgepole pine caused by the mountain pine beetle. A secondary objective was to measure cumulative mortality. Criteria in design were that the survey should provide mortality estimates on a forest-wide basis and that the overall design be flexible for application to very large areas, such as states or Regions.

AREA

The survey area composed a 397,000 acre mountain pine beetle outbreak on the Targhee National Forest in southeast Idaho (Fig. 1). This area, due west of Yellowstone National Park and south of the Continental Divide (Centennial Range), has been under attack by mountain pine beetle since the mid 1960's. The area is almost pure lodgepole pine type with lesser amounts of Douglas-fir, Engelmann spruce, subalpine fir, whitebark and limber pines, and aspen. The survey area generally consists of two large plateaus interspersed with abruptly rising mountains, long ridges, low buttes, and is bisected by a series of deep gorges. Elevations in the lodgepole pine type range from slightly under 6000' in the southwest to over 8000' in the northeast.



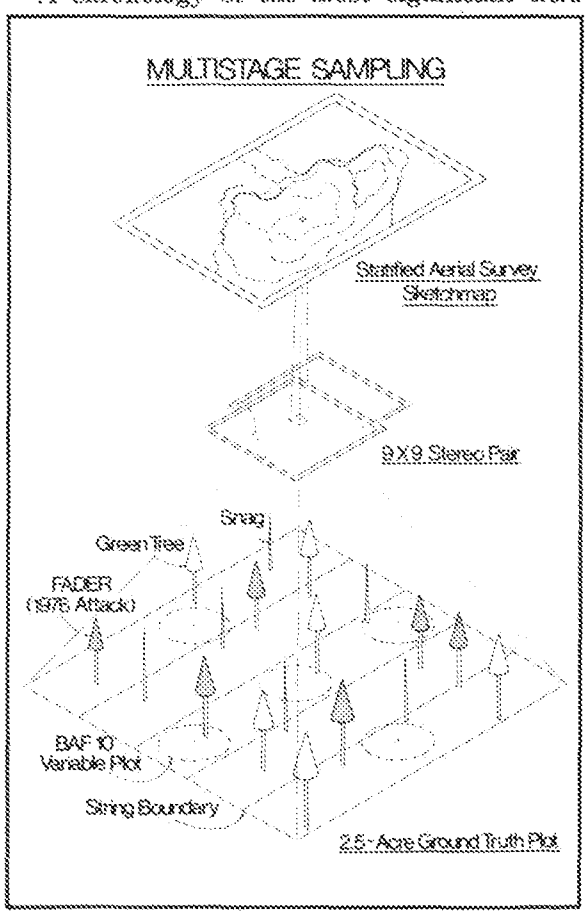
3. Distribution and number of lodgepole pine killed by the mountain pine beetle in 1978 as determined from a 1977 aerial sketchmap survey.

METHODS

Survey Design

The basic survey design was a multistage sampling system stratified into three intensity classes or strata. Stratification was done by aerial sketchmapping, which has proved to be an effective base for multistage surveys (Wert and Roettgering 1968, Heller and Wear 1969). Each stratum was sampled independently with large scale (1:6000) color aerial photography, followed by ground truth. A series of randomly selected ground samples permitted adjustment of the large photo sample for number and volume of trees killed by linear regression. Variable plot clusters were established in each ground plot to determine the basal area ratio of the residual live stand to dead (Fig. 2).

A chronology of the most significant field survey events and procedures is shown in the Appendix.



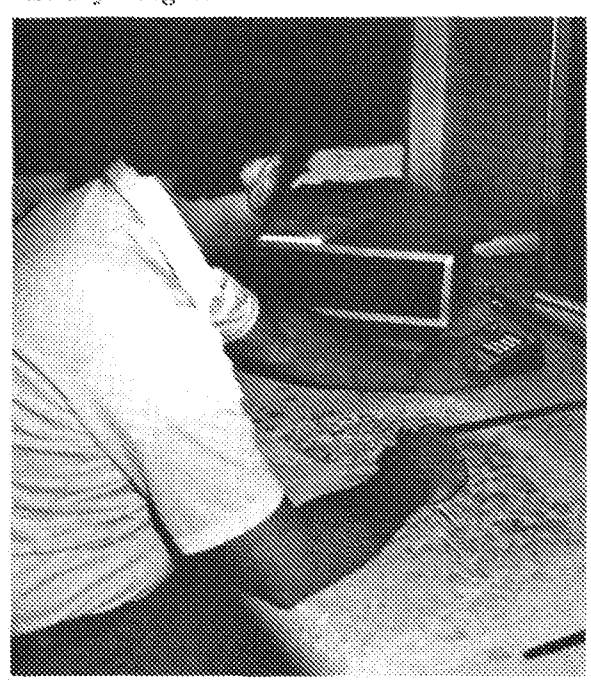
2. Diagram showing the stages and procedures used during the multistage survey, Targhee National Forest.

Aerial Sketchmapping

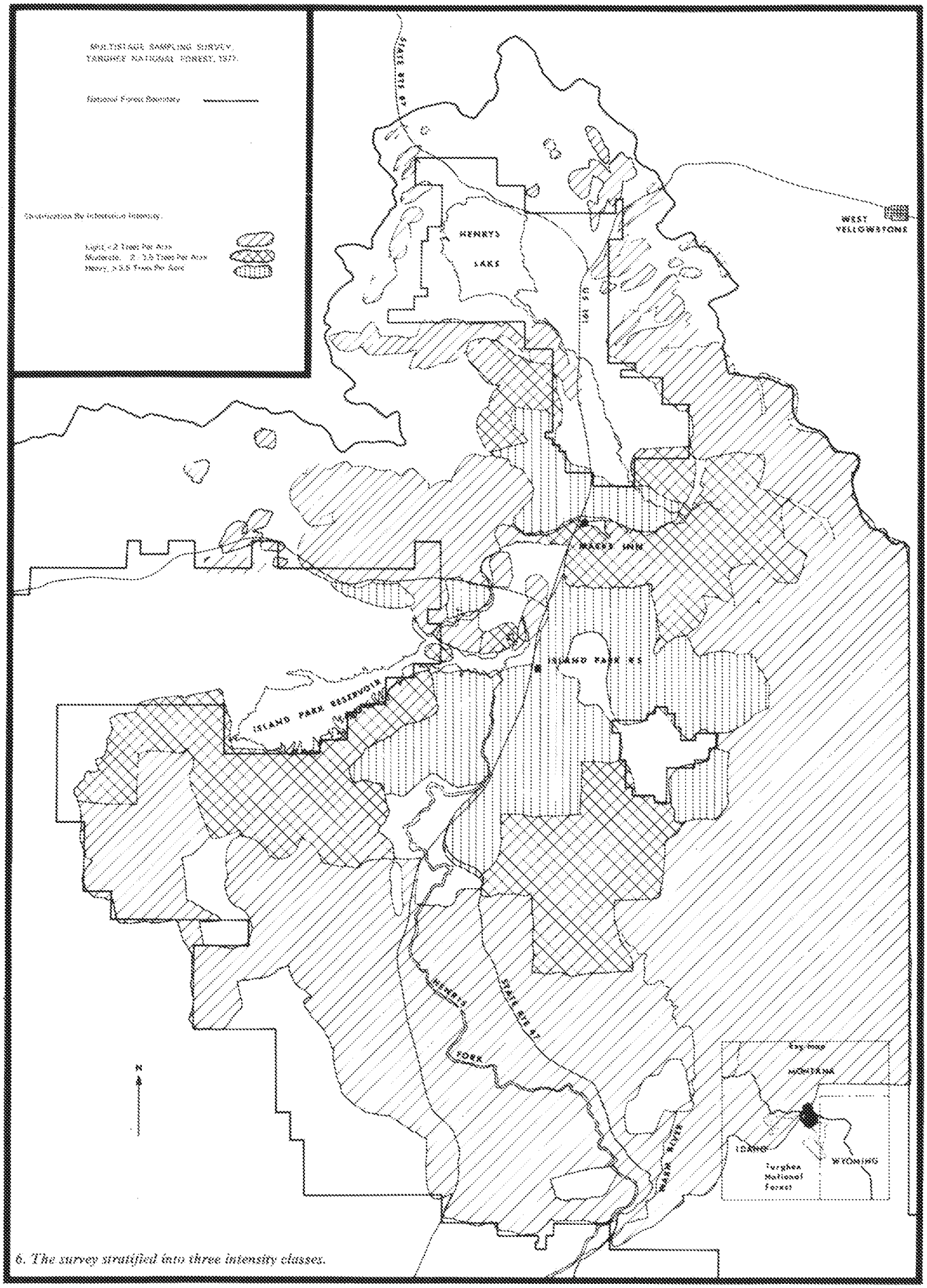
The outbreak and surrounding area was mapped on July 6-7, 1977, from a light aircraft flying from 300' to 1200' above terrain. The single observer, following drainage patterns for orientation, estimated the number of faded (1976 attacks) lodgepole pines within recognizable terrain features. This information was sketched on a 1:126,720 scale (1"=two miles) planimetric map (Fig. 3). Eight hours of flying were required to fly approximately 500,000 acres.

Stratification

Following the first day of sketchmapping, that portion of the finished map was traced onto a mylar overlay, and the areas of the polygons computed with a Neumonics electronic planimeter (Fig. 4). The number of trees per acre was then computed for each polygon. There were 222 individual polygons ranging in size from 28 acres to slightly over 5500 acres. The overlay and computations were completed following the last day's flight.



4. Computing polygon areas with an electronic planimeter.

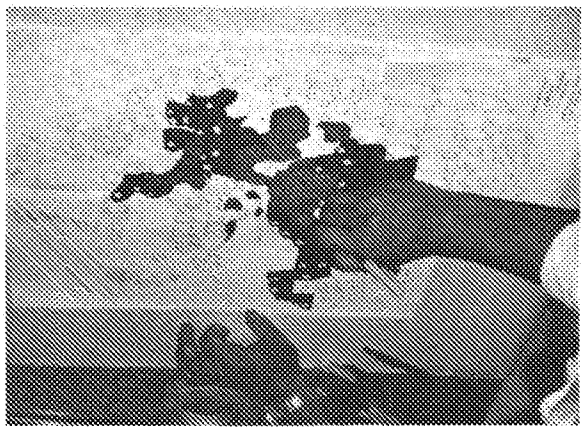


6. The survey stratified into three intensity classes.

The stratification process began by a computerized numerical listing of the polygons by density (trees per acre), area, and number of faders.

The survey area was separated into three distinct strata: less than two trees per acre; two to 3.5 trees per acre; and greater than 3.5 trees per acre (Table 1). The selection of these strata intervals was a combination of *a priori* knowledge, arbitrary judgment, and a preplanned attempt to select approximately an equal number of faders in each stratum. In this way the heavier strata, which were progressively smaller in area, would be sampled more intensively than the lighter strata.

Following strata selection, the polygons were grouped into their respective strata and plotted on a 1:126,720 base map (Figs. 5 and 6). The strata were color coded, making it possible to observe the distribution of the combined polygons within their respective stratum. With the exception of 14 polygons, they merged into three well defined groups or strata. The 14 aberrant polygons were then combined with their closest stratum, but in no case was it necessary to jump two stratum, i.e., from low to high or high to low.



5. Plotting the strata on a 1:126,720-scale map.

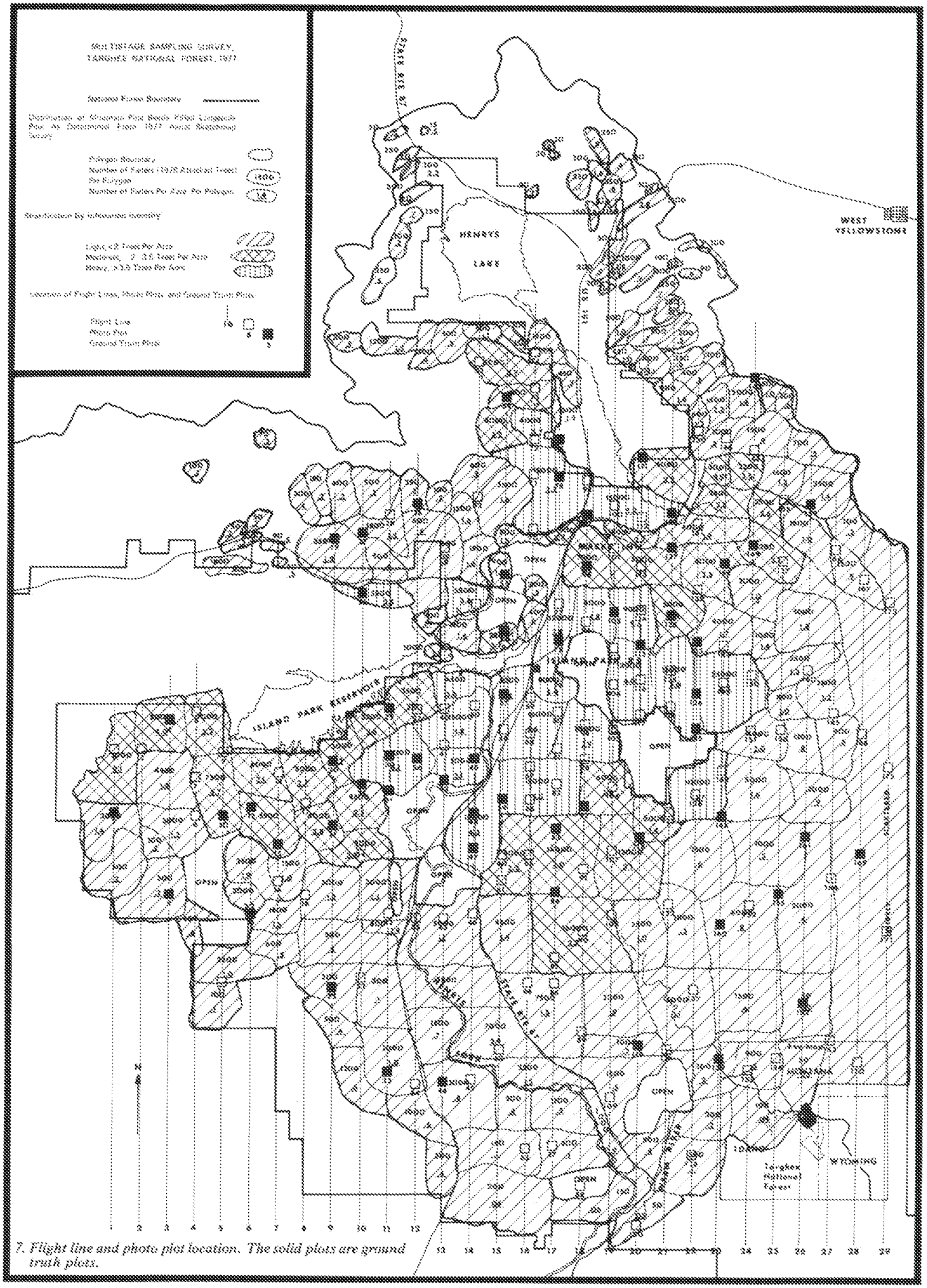
Photo Mission Planning

Flight lines were north-south and spaced one mile apart. Photo plots were equally spaced along each flight line within strata (Fig. 7). The first plot in each stratum was selected by random starts. The original plan was to locate 70 photo plots in the heavy stratum, 50 in the medium stratum, and 60 in the light stratum. However, due to normal operational problems such as overflying and some plots falling out of type, this distribution was not obtained. Final distribution was 72, 47, and 54, for a total of 173 photo plots.

Flight lines and plot locations were then transferred to topographic maps and the elevation of each plot recorded. An elevational profile of each flight line was drawn as a basis for determining aircraft altitude. Abrupt, or gradual and relatively long elevational changes required periodic breaks in aircraft altitude to maintain the desired scale. These altitude changes, photo plot locations, and flight lines were marked on 1:80,000 black and white aerial photographs used for aircraft navigation.

Table 1. Stratification by intensity class and allocation of photo samples per stratum as determined from aerial sketchmap data, Targhee National Forest, 1977.

	STRATIFICATION				ALLOCATION				
Strata	Class Boundaries (T/A)	No. of Polygons	Total Acres (A)	Est. No. of Faders	Plot Size in Acres (PSU)	No. of PSU's in A	No. of PLOTS		Percent Sample
							Planned	Actual	
L	<2	162	272,243	212,035	40	6806	70	72	1.1
M	2-3.5	38	72,883	194,900	40	1822	50	47	2.6
H	>3.5	22	51,680	252,000	40	1292	60	54	4.2
TOTAL		222	396,806	658,935	—	9920	180	173	—



7. Flight line and photo plot location. The solid plots are ground truth plots.

In July prior to the first aerial photo mission, several areas containing infested lodgepole pine were established to monitor the rate of tree fading and to permit project personnel to differentiate new and old faders firsthand. The sites contained several hundred infested and dead trees and ranged in elevation from 6700 to 7500'. On July 18, 77% of the trees at the lower elevation exhibited some degree of fading, while only 35% of the trees in the upper elevation had started to fade. However, by the first photo mission on August 10, fading was practically complete.

Aerial Photography

The photo missions, originating from West Yellowstone, Montana, were flown in nine hours over a four-day period, August 10-13, by a Forest Service Aero Commander and crew. Ektachrome SO-397 stereo triplets were taken near each predetermined point with a Zeiss RMK 21/23 aerial camera at a photo scale of 1:6000. All photography was taken between 11a.m. and 2p.m. MDT. Daily build ups of cumulus clouds caused early termination of flights; otherwise, the entire mission could have been flown in less than seven hours over a two-day period.

Aircraft altitude was recorded for each elevational change in each flight line by monitoring two altimeters. One altimeter was set at standard barometric pressure of 29.92", while the second altimeter was at the recommended setting during takeoff and periodically reset during the flight. The recorded altitude over any one plot was the mean difference in altitude between the two altimeters. The exposed film (three 200' rolls) was shipped to Eugene, Oregon, for processing and returned to Salt Lake City on August 19.

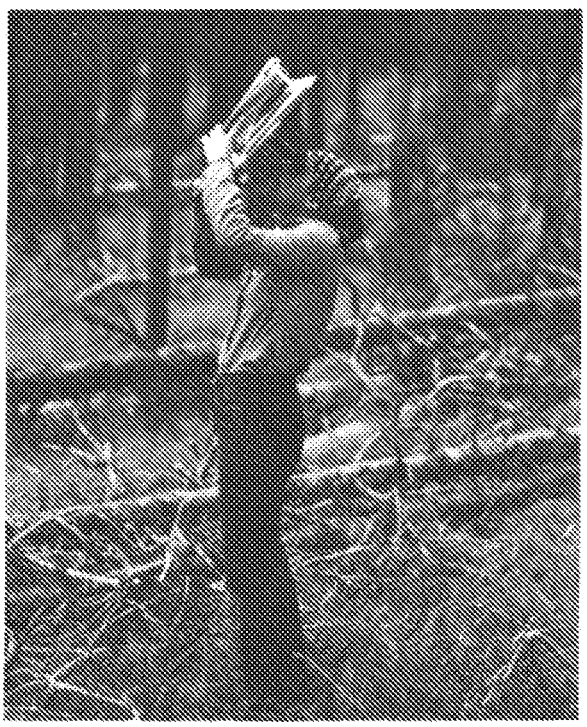
Photo Interpretation

Photo interpretation was done in Island Park, Idaho, by two experienced and three inexperienced photo interpreters during the period of August 24 to September 1. Prior to the actual photo interpretation, the interpreters were taken to those training sites that appeared on the photos, where they were able to observe and identify individual trees with known fading characteristics. Field identification was done with portable solar-illuminated stereo viewers (Fig. 8).

The primary sample unit was the photo plot, 40 acres (20 x 20 chains) in size, and subdivided into sixteen 2.5-acre subplots. A series of clear acetate templates inscribed with plot and subplot boundaries, representing a range of scales (1:5400-6600), were prepared. A template of the approximate scale was chosen and overlaid in the center of the effective area of each stereo pair. The 40-acre plot was systematically scanned with Old Delph stereoscopes, and tree counts recorded by subplot. Only new faders (1976 attacks) were counted; old dead could not be readily discerned.

Ground Truth Acquisition

Twenty 2.5-acre plots within each of the three strata were randomly selected (without replacement) to establish photo-ground correlations. The plot corners and boundaries of the 2.5-acre subplot were etched on the emulsion side of the film.



8. Ground plots were located and surveyed by use of portable stereo viewers.

Ground truth of the 60 plots was obtained by three 3-man crews during the period of August 29 to September 20. The procedures used on the plots were:

1. Ground check plots were generally located by use of the 1:80,000 scale black and white photography. Once near the plot, the large scale color transparencies were used with stereoscopes (Fig. 8).
2. Plot corners were located and the exterior boundaries were traversed and designated with a continuous string line. The plot was then sectioned into one-chain wide strips, also with string, to facilitate ease of examination and orientation.
3. Within the plot, all faders and snags 5" DBH and larger were located, and their diameters recorded. The heights of at least two trees in each diameter class were also measured and recorded.
4. A variable five-plot (BAF 10) cluster was established with the central plot located at plot center. The four remaining plots were established at each of four cardinal directions at two-chain intervals from center. In each plot, using a Spiegel-Relaskop on a jake staff, all live trees by species and all dead pine 5" DBH and larger were recorded. The status of borderline trees was determined by use of the appropriate plot radius factor (2.75 X DBH).
5. The distance (boundary) between two adjacent corners was measured as a check on scale determination.

Data Analysis

Procedures for estimating the total volume loss for current faders involved estimates of (1) the total number of faders from the aerial photo samples, (2) the relationship between ground truth and corresponding photo counts, (3) the average volume per tree, and (4) the total volume loss.

1. Estimate of faders from P.I. sample

Since the basic sampling unit was a 40-acre photo plot, the first calculation was to adjust the photo counts from each photo to a 40-acre basis. The actual size of each photo plot was determined by a scaling process. The adjusted photo count was then calculated by:

$$\left(\begin{matrix}\text{Adjusted}\\ \text{photo count}\end{matrix}\right) = \left(\begin{matrix}\text{Photo}\\ \text{count}\end{matrix}\right) \cdot \left(\frac{40.0 \text{ acres}}{\text{calculated acres}}\right)$$

Example: 200 faders counted on a photo that was scaled to be 44.5 acres. The adjusted photo count would be $200 \times (40.00 \div 44.5) = 179.8$ faders.

The strata estimate for faders was then estimated by:

$$\left(\begin{matrix}\text{Total}\\ \text{faders}\end{matrix}\right) = \left(\begin{matrix}\text{Total}\\ \underline{\text{sampling units}}\\ \text{sample site}\end{matrix}\right) \cdot \left(\begin{matrix}\text{Sum of all}\\ \text{adjusted}\\ \text{photo counts}\end{matrix}\right)$$

$$\hat{X} = \frac{M}{m} \sum_{i=1}^{m} X_i,$$

where the total sampling units were determined for each stratum by dividing the stratum acres by 40.0, and m is the photo sample size.

2. Estimating the relationship between ground and photo counts

A subsample of twenty 2.5-acre ground plots was made to determine (or to correct) the differences between the photo interpretation counts and the actual ground count for faders. The ground counts of faders as well as the corresponding photo counts were converted to a per-acre basis. The prediction model was derived by standard linear regression techniques using the 20 pairs of data, ground counts (Y, dependent variable), and photo counts (X, independent variable).

Double sampling with regression was then used to combine the estimates from steps 1 and 2 to obtain the stratum estimates of the current faders. The procedure was:

$\overline{\overline{Y}} = \overline{y} + b(\overline{\overline{X}} - \overline{x})$, where

$\overline{\overline{Y}}$ is the combined estimate of the faders per acre;

$\overline{y}$ is the average of the ground counts per acre;

b is the regression estimate of the slope;

$\overline{\overline{X}}$ is the average number of faders per acre counted on all of the photos; and

$\overline{x}$ is the average number of faders per acre counted on the matched sample from the photo.

3. Estimating the average volume per tree

From the tree height measurements, an average height was calculated for each DBH class. Volume per tree by DBH class was computed by the formula:

$\text{Volume} = B_o + B_1 D^2 H$,

where volume is expressed in gross cubic feet, B_o and B_1 are previously determined regression coefficients, D is the diameter, and H is the average height.

The equation[4] used was:

$\text{Volume} = .106505 + .00258749 D^2 H$

The next step was to estimate the average volume per tree for each plot. This was done using a weighted average based on the number of trees falling within each DBH class. This calculation follows:

$$\begin{pmatrix}\text{Volume}\\ \text{per}\\ \text{tree}\end{pmatrix} = \left(\frac{\Sigma(\text{trees}_i)(\text{volume}_i)}{\Sigma(\text{trees}_i)}\right)$$

where i represents the DBH class.

4. Estimating the total volume loss

The stratum estimates of volume loss were estimated by using the double sample regression estimate of faders per acre times the stratum acres times the average volume per tree:

$$\begin{pmatrix}\text{Volume}\\ \text{loss}\end{pmatrix} = \begin{pmatrix}\text{Strata}\\ \text{acres}\end{pmatrix} \cdot \begin{pmatrix}\text{Faders}\\ \text{per acre}\end{pmatrix} \cdot \begin{pmatrix}\text{Volume}\\ \text{per tree}\end{pmatrix}$$

Procedures for Estimating Standing Dead Volume

The procedure for estimating old dead relied only on the ground data since no photo interpretations were made. The estimates for each stratum were based solely on the 20 ground plots. An assumption was made that the twenty 2.5-acre plots were randomly selected from all possible 2.5-acre plots in the stratum.

Volume estimates per plot were computed.

Then, the total volume loss for each stratum was determined as follows:

$$\begin{pmatrix}\text{Volume}\\ \text{loss}\end{pmatrix} = \left(\frac{N}{n}\right)\left(\sum_{i=1}^{n} (\text{volume per plot})_i\right)$$

where N was the number of possible sampling units in a stratum (stratum acres÷2.5), and n was the number of ground plots.

4 Salmon-Ashley volume equations based on felled tree study by the University of Idaho. USDA Forest Service, Ogden, Utah.

RESULTS

Correlations between photo counts and ground counts were generally good, considering the fact that three of the photo interpreters were inexperienced. In fact, there was no significant difference between the coefficient of determination (R^2) values for unexperienced and experienced interpreters. Of the 60 photo-ground comparisons, 59 of the photo counts were less than the ground count (omission errors) while only one photo plot was counted as having more trees than the ground count (commission error). This overestimate was in the medium strata, but in a recalculation exercise to determine its effect, its omission did not change the R^2 value significantly (0.83 to 0.84).

Total mortality over the 396,806 acres during 1976 was 3,609, 627 trees and 64,761,000 cubic feet. Standard errors of these estimates were 8.2 and 9.7 percent respectively (Table 3).

Prior to 1976, total mortality by the mountain pine beetle amounted to 249,515,000 cubic feet and 17,751,000 trees (Table 4). It bears emphasis, however, that these estimates were derived solely from the ground plot data and not by double sampling. The standard error for total volume was 14.6 percent. Combined estimate for total mortality, 1976 and prior, was 314,270,000 cubic feet or approximately 54 trees and 792 cubic feet per acre.

The variable plot estimates of the ratio of the basal area of green residual stand greater than 5" DBH to total dead was approximately 63% (Table 5).

Table 2. Relationship of ground to photo counts and regression estimates per stratum for mountain pine beetle photo survey, Targhee National Forest, 1977.

Strata	Double Sample Regression Estimate Faders per Acre		Linear Regression of Faders on Ground (Y) to Faders on Photo (X)			
	Mean	S.E.	Intercept	Slope	R^2	S.E.
1	5.501	.746	1.909	1.393	.880	1.956
2	14.815	2.642	3.707	1.315	.832	6.835
3	19.974	1.879	2.537	1.524	.881	4.491

Table 3. Estimates of numbers of trees and volume of lodgepole pine killed by the mountain pine beetle in 1976, Targhee National Forest, 1977.

Strata	Acres	No. of Faders	Standard Error	Volume per Tree	Standard Error	Total Volume	Standard Error
				(cu. ft.)		(M cu. ft.)	
L	272,243	1,497,609 (13.6)*	203,093	18.86	1.94	28,245 (17.1)*	4824
M	72,883	1,079,762 (17.8)*	192,198	16.19	1.31	17,481 (19.6)*	3427
H	51,680	1,032,256 (9.4)*	97,032	18.44	1.12	19,035 (11.2)*	2133
TOTAL	396,806	3,609,627 (8.2)*	295,976	17.94	1.74	64,761 (9.7)*	6290

*Percent standard error

Table 4. Estimates of numbers of trees (snags) and volume of lodgepole pine killed by the mountain pine beetle *prior to* 1976, Targhee National Forest, 1977.

Strata	Acres	No. of Trees (Snags)		Volume per Snag (cu. ft.)	Volume Killed	
		per Acre	Total (M trees)		Total	S.E.
					(M cu. ft.)	
1	272,243	46.73	12,722	14.18	180,382 (18.6)*	35,546
2	72,883	42.22	3,077	14.08	43,332 (17.1)*	7,418
3	51,680	37.78	1,952	13.21	25,801 (13.9)*	3,581
TOTAL	396,806	—	17,751	14.06	249,515 (14.6)*	36,488

*Percent standard error

Table 5. Estimates of basal area in percent by stratum and species composition of stands in survey area, Targhee National Forest, 1977.

Strata	Pine		Douglas-fir Live	True Fir Live	Aspen Live	Total
	Live	Dead				
1	63.9	26.2	9.2	0.7	—	100
2	56.3	29.1	10.8	3.8	—	100
3	65.1	32.6	0.3	1.1	0.9	100
WEIGHTED MEAN	62.7	27.9	8.3	1.3	0.01	100

Table 6. Comparison of number of faders estimated by aerial sketchmapping and multistage sampling, Targhee National Forest, 1977.

Strata	Sketchmapping	Multistage Survey	Ratio Sketchmap:Survey
1	212,035	1,497,609	1:7.1
2	194,900	1,079,762	1:5.5
3	252,000	1,032,256	1:4.1
TOTAL	658,935	3,609,627	1:5.5

DISCUSSION

Stratification into intensity classes reduced population variance and resulted in an overall lower sampling error than if no stratification had been attempted. In forest sampling, stratification becomes even more important with those bark beetles and other pests that are contagious in distribution and kill their hosts, in groups and other nonrandom patterns. In the formative or endemic years of a mountain pine beetle outbreak in lodgepole pine, this pattern generally occurs. However, in contiguous lodgepole stands that are typical of the Targhee (see cover illustration) and elsewhere, once the transition from the so called endemic to epidemic period occurs and the single tree pattern changes to groups and these groups eventually merge, the distribution becomes relatively homogenous. This more or less random pattern, together with extensive stratification, was largely responsible for the low standard errors.

Stratification by aerial sketchmapping was successful, although the overall estimation of infestation density (tree counts) was very inaccurate. In each stratum, the aerial sketchmapping grossly underestimated the number of trees (Table 6).

The aerial sketchmapping technique is highly subjective. In spite of this limitation, however, aerial sketchmapping has many other uses and applications, and will continue to be an important and indispensable tool in forest pest management.

RECOMMENDATIONS

The results of this survey and the survey conducted in the Black Hills was reviewed by a specially formed Working Group on March 29 and 30, 1978 (see Appendix). The Group recommended that similar but modified surveys be conducted in 1978 to measure annual mountain pine beetle damage in lodgepole pine on the Beaverhead and Gallatin National Forests in Montana and again in ponderosa pine in the Black Hills National Forest in South Dakota and Wyoming. The most significant changes and modifications recommended by the Working Group follow:

1. Medium-scale (maximum 1:30,000) high resolution panoramic (5 x 50") CIR photography will be taken of the Gallatin, Beaverhead, and Black Hills infestations during 1978. The purpose is to test this large format film for stratification and direct sampling.
2. Independent of the large format photography, the infestations will be sketchmapped and sampled with large scale (1:6000) color photography.
3. Two strata will be used instead of three.
4. There will be approximately 100 photo plots in the heavy stratum and 75 in the light stratum. Selection will be random.
5. The ground plot will remain 2.5 acres. There will be approximately 60 plots in the heavy stratum and 30 plots in the light stratum. To minimize travel between ground plots, there will be two ground plots in each of the chosen plots.
6. Photo and plot selection will be by probability proportional to size (pps). This will reduce the probability of selecting plots having zero or low counts.
7. In the spring or early summer prior to aerial photography, training areas containing infested trees (1977 attacks) and old faders (1976 attacks) will again be located and marked. They will serve as training areas for photo interpreters and field crews in differentiating between the two attack periods.

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Wert, Steven L., and Bruce Roettgering. 1968. Douglas-fir beetle survey with color photos. Photogram. Eng. 34:1243-48.

APPENDIX

Chronology of Main Survey Field Events and Procedures

Targhee National Forest, 1977

Dates	Event	Man Day
7/6, 7	Aerial sketchmapping	2
7/6-8	Mylar overlay and area computations	4
7/13	Training site establishment	1
7/19-22	Stratification	6
7/25-26	Preflight planning	4
7/27-28	Monitor training sites	2
8/10-13	Aerial photography	12
8/13	Film airfreighted for processing	½
8/17-18, 21	Field preparation	3
8/19	Processed film received	½
8/19-20, 22-23	Photo and map indexing	8
8/24	Photo interpreter training	6
8/25	Photo interpretation started	—
8/29	Ground crew training	8
8/30	Ground truth started	—
9/2	Photo interpretation completed	40
9/20	Ground truth completed	150

Mountain Pine Beetle Working Groups

Davis, California

Participants During December 14-15, 1976

Wayne Bousfield	FI&DM, R-1
Donn Cahill	FI&DM, R-2
Wilmer Bailey	FI&DM, R-2
Douglas Parker	FI&DM, R-3
Donald Curtis	FI&DM, R-4
Bruce Roettgering	FI&DM, R-5
Dennis Hart	FI&DM, R-5
Jule Caylor	FI&DM, R-5
John Wear	FI&DM, R-6
John Wortendyke	FI&DM, R-6
Gary Dixon	RM
C.J. Demars	PSW
Bill Ciesla	FI&DM, MAG
Dave Drummond	FI&DM, MAG
Bob Young	FI&DM, MAG
Dave Grimble	FI&DM, MAG
Bill Klein	FI&DM, MAG

Participants During March 29-30, 1978

Wayne Bousfield	FI&DM, R-1
Mark McGregor	FI&DM, R-1
Wilmer Bailey	FI&DM, R-2
Donn Cahill	FI&DM, R-2
Ken Gibson	FI&DM, R-4
Jule Caylor	FI&DM, R-5
John Pierce	FI&DM, R-5
Nancy Norick	FI&DM, R-5
John Wear	FI&DM, R-6
Ray Allison	WO-E
C.J. Demars	PSW
Bob Young	FI&DM, MAG
Bill Klein	FI&DM, MAG

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